the nut was flush with the surface of the bark or even a little countersunk. Some few were inserted so as to protrude more or less. Some were inserted about a quarter of the length of the nut but very tightly at that. Here and there was a nut too small to fill the hole made for it, but the orifice of the hole was too small to permit the nut to be easily taken out. There were many empty holes and some holes only partly drilled. Many of the acorns had been opened and the shells left in the drilled cavities. We did not find any opened almonds (except in the one instance noted) although many empty holes were found where almonds had been or which had been drilled for almonds. The difference between holes drilled for almonds and those drilled for acorns is very marked. We could not detect any disposition to drill the holes so that they would not hold water. All were about horizontal. Several almonds in the drilled holes looked as if an effort had been made to open them. The opening of an almond presents no difficulty to a bird that can cut a hole in dried oak.

Of course, acorns must be abundant all about. Mr. Chalmers said there were two almond trees on the Thresher ranch and I was told that until this spring there had been an almond orchard less than a half mile to the north.

Oak trees and California Woodpeckers have existed together for so long a time that they may be considered coetaneous. But almonds are not indigenous in California. The habit of storing acorns may have developed very gradually, but to whatever extent this bird has acquired a habit of storing almonds the development must have been of recent origin. The subject suggests many interesting possibilities and theories but I do not feel competent to go into that phase of the matter.

A gentleman living at Liveoak told me he had seen almonds stored in electric light or telephone poles at Pennington, eight miles east of Liveoak, and that he had heard of walnuts being stored in the same manner, but he could not give any details about the walnuts.

Berkeley, California, March 31, 1921.

THE FLOCK BEHAVIOR OF THE COAST BUSH-TIT

By R. C. MILLER

WITH MAP

THE STUDY of birds has had a tendency in the past to be extensive rather than intensive. The ornithologist has been engaged with the problems of distribution and speciation, of migratory instincts and migration routes, of coloration and adaptation, of food and economic importance, all of which, while thoroughly justifiable, have involved a generalized consideration of a large number of species. It has seemed to the writer that much is to be gained from a careful study of a single species, or even, as in the case of this paper, of a single aspect of the life history and relations of one species.

The study of birds from a behavioristic standpoint has been relatively neglected, and those investigators who have given the matter some attention have usually gone to one of two extremes: the field observers, being better naturalists than psychologists, have interpreted the behavior of birds in an extravagantly anthropomorphic fashion; and the experimentalists, being better psychologists than naturalists, have with amusing seriousness taken caged birds into the laboratory and assumed that they would there behave in normal fashion (cf. Porter, 1904 and 1906). What we need would seem to be a new science of "field psychology" which should combine in due proportions the observational and experimental methods.

The studies in behavior which follow* have been limited to the coast race of the Bush-tit (*Psaltriparus minimus minimus*), which occurs in considerable numbers on the Berkeley Campus, ranging over more or less definite areas of live oak and chaparral associations, or cultivated shrubbery. The birds are gregarious during the greater part of the year, pairing off in February or March for the breeding season, and congregating into flocks again when the young are reared. The flock formation is relatively simple and loose, so that a much better opportunity is offered for analyzing flock-behavior than would be the case with birds manifesting a more complicated flock organization. Moreover, observation has convinced me that the birds remain pretty much in the same locality all through the winter, so that the complication of a changing series of flocks is not introduced.

The University Campus and neighboring hills and canyons have served as the field of operations.

Three flocks of Bush-tits have frequented the territory under observation during the past winter (1920-21). The largest of these numbered about seventy individuals, the other two, respectively, twenty-five and twenty. These figures are based on averages, as the number of birds in a flock often varies in a puzzling manner, even while under actual observation. Such discrepancies are doubtless due in part to the difficulties involved in making accurate counts. The little creatures are in constant motion, popping in and out among the bushes, appearing and disappearing in a confusing manner, so that they can be successfully counted only as they occasionally straggle across an open space along the forage route. But allowing for a margin of probable error, the impression is still conveyed that there is an actual variation in the number of birds in a particular flock at different times, individual birds perhaps becoming lost, or passing from one flock to another.

These three flocks were observed on August 28 and again on October 16 and subsequently, but not until the middle of the winter did the idea occur to me that they might represent the entire Bush-tit population of the region under observation. Thereafter I made a practise of "rounding up" the Bush-tits in the locality from time to time, always beginning by scouring the campus thoroughly, then working up Strawberry Canyon. In every case I was able to locate the three flocks above mentioned.

In addition to these periodic round-ups, I have made a practise of keeping record of every flock of Bush-tits seen on the campus, with time of day, general

*NOTE.—This paper is chiefly an abridgement of a Master's thesis written at the University of California during the current year. I am indebted to Professor Joseph Grinnell, under whose guidance this work was undertaken, for many helpful suggestions as to method, as well as much valuable information from his personal observations.—AUTHOR.

direction of movement, and numbers, either actual or estimated. I find these observations to agree with my assumption of three flocks, one large, the other two smaller and of nearly equal size.

It is manifestly impossible to be absolutely certain that flocks of similar size observed in the same region at different times are identical; but repeated observation has given the impression very strongly that the flocks observed in February are in general the same ones seen in August preceding, though individual birds probably sometimes pass from one flock into another. I may add that I have never observed the Bush-tits more than one hundred yards up along the sides of a canyon, and it may be that relatively small hills, especially when sparsely clothed with vegetation, form to them a somewhat effectual barrier. I think it extremely unlikely, for instance, that the number of birds in Strawberry Canyon would be augmented by an invasion of Bush-tits from Claremont Canyon, or vice versa. The topography of the region furnishes additional reason for believing that the birds I have had under observation are limited to the narrow range which I have assigned to them.

I early noted that, as Swarth (1914, p. 501) has observed, the Bush-tits appear with considerable frequency in certain tracts of trees and bushes on the campus, so as to suggest the possibility of their having definite forage routes, which are covered at more or less regular intervals. Working on this hypothesis, I undertook to map out the forage routes of the different flocks, and, by taking note of the intervals at which they recurred at certain definite points, I thought perhaps to be able to prepare a schedule of their movements. At first I seemed to have some degree of success with this part of the work, and on one or two occasions I was able to predict the whereabouts of a particular flock from my hypothesis, and to find the birds exactly where I had expected them. But frequent subsequent failures have led me to conclude that success on these occasions was entirely accidental; and as I now look through my notes, I am unable to trace out anything approaching systematic progression over a well defined route. Any impression of regularity in the movements of the birds is doubtless due to mechanical causes, such as relative density of shrubbery and other foliage in different parts of the range.

A method of observation to which I have been partial is that of attaching myself to a particular flock of Bush-tits and following it about for a considerable period of time. For purposes of illustration, I wish to record in some detail the wanderings of a flock observed in Strawberry Canyon on February 11. A map of the region in question has been introduced (fig. 24), which should be consulted in interpreting the following account.

9:35 A. M.—Flock of 16 Bush-tits observed at A. Foraged through bushes to B; 5 birds crossed road to C, then straggled back again to B, then to D; one returned to C and foraged alone for several minutes, then was joined by 6 others. The remainder of the flock retraced to A, then moved on to E, to be followed shortly by the stragglers at C. The entire flock then moved across the road to F, which marks the edge of a small but dense thicket.

From F the flock foraged in a leisurely fashion through to the east side of the thicket at G, then along its edge to J. At G one bird left the flock and crossed to H, where it foraged about 8 minutes, then rejoined the flock at I. From J the entire flock then retraced to I, crossed over to H, then moved slowly on to K and finally L, where they foraged in a live oak for a considerable period of time. At * one bird flew down and foraged for a few moments in the grass, a quite unusual type of behavior, which I have seen on only one other occasion.

One bird presently moved across to the bay tree at M, and was followed shortly afterwards by two more. Three others retraced to H, and the main body of the flock straggled after. The birds at M, finding themselves left behind, hastened after their companions. All now returned to the thicket at N, foraged slowly over to O, then down to P, and finally crossed the road to Q in their characteristic straggling fashion, one bird venturing out and being followed shortly by the others.

In counting the birds as they flew across the road at this point, I was surprised to find that the flock now numbered 21; 5 stragglers, either of this or some other flock, had been gathered up in the thicket.

The flight from P to Q occurred at 10:45, the flock having remained for almost an hour in a patch of brush about one-eighth acre in extent.

The birds foraged in the one large oak at Q for 24 minutes. At 11:00 o'clock one bird ventured to another oak at R, but none of its companions followed, and it soon returned. At 11:09 a bird flew across to S, but seemed timorous and at once returned

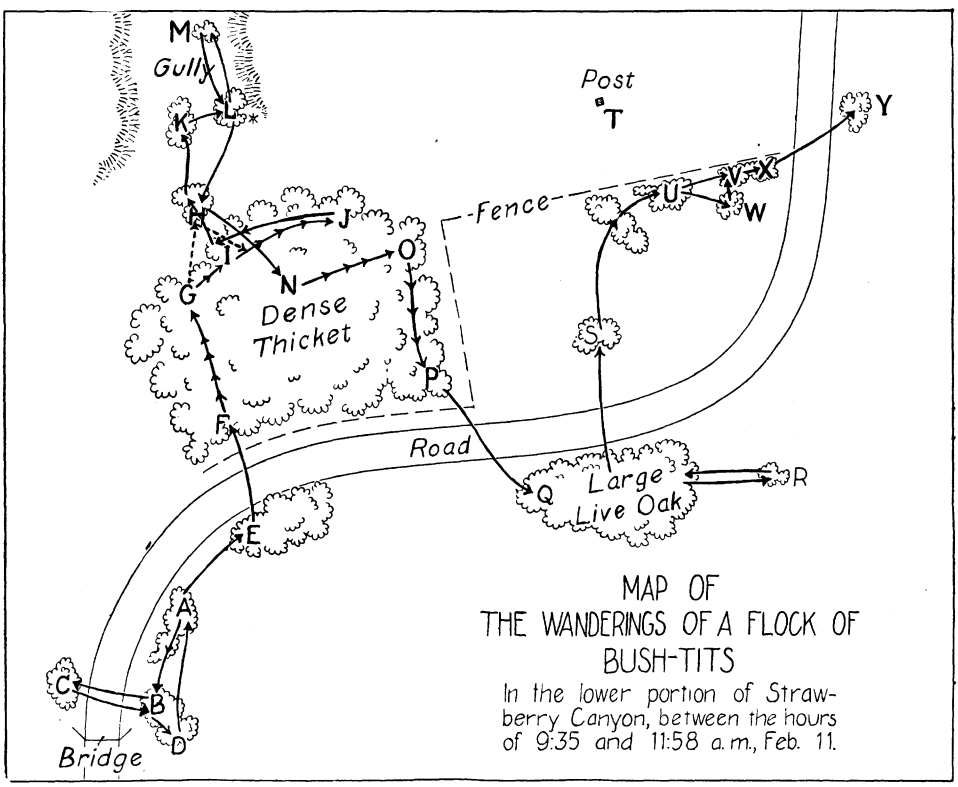

Fig. 24.

to Q. Then another ventured across, and the flock presently followed in their usual manner. At T a Sparrow Hawk appeared and perched on a near-by post, but was not noticed by the Bush-tits.

At U the flock became divided, about half remaining at V, the rest foraging in a fallen oak (still green) at W. Later the two divisions rejoined, with the exception of 4 individuals (2 pairs?) which remained behind and did not rejoin the flock as long as I observed them. I interpreted this as an indication of the advent of the mating season, when the flocks gradually break up into pairs. Subsequent observations showed the flocks to be rapidly dwindling, and tended to confirm this opinion.

While the birds were in the oaks, a California Jay swooped in among them, causing great alarm for a moment, until the intruder was identified. This reaction to Jays I have frequently noticed, although as far as I know the larger bird does not harm the Bush-tits, and they manifest no fear of a perching Jay.

About noon one bird flew across the road to the clump of oaks marked Y, and was followed by 13 others. Three more followed hurriedly a little later. I did not observe the birds further.

Thus it is seen that the flock when first observed was composed of 16 individuals, that 5 were added while the birds were in the thicket, and that 4 later left the flock, so that the number remaining when observations were discontinued was 17. This affords a good example of the puzzling fluctuation in numbers which I have above mentioned as leading me to conclude that the flock organization is relatively loose and that birds probably pass from one flock to another with considerable frequency.

Doubtless the reader, if he has had the patience to follow the observations above recorded, has been struck with the lack of system or direction and the unnecessary retracing of routes manifested by the birds, their behavior in this respect being somewhat suggestive of that which Mark Twain has attributed to ants in his classical essay on that subject. The method of progress of the birds may be analyzed as follows:

The flock is foraging, let us say, in the outer foliage of an oak tree. The twigs and leaves are examined in quite a thorough manner, the birds inspecting them from above, or clinging, as they do frequently, upside down and examining the under surfaces. Presently some individual finds the forage poor; no more scale insects or aphids are to be found in its immediate vicinity; it begins to look about in search of fresh fields and pastures green. Yonder is a clump of chaparral that looks promising. A few yards of open space must indeed be traversed in order to reach it, and Bush-tits have a native abhorrence of open spaces; they are natural agoraphobiacs. But hunger is a strong stimulus. The bird hesitates a moment, then darts out and with hurried, undulating flight crosses to the chaparral.

Now other individuals of the flock find food beginning to run short in the oak foliage. They too see the near-by clump of chaparral; they have seen their companion make the flight successfully; they hear his notes, perhaps indicating that he has found food; they themselves are encouraged to make the venture.

Now the impulse spreads; in groups of two or three or five, others dart across from the oak to the chaparral, until shortly the whole flock has moved to the new location.

I would not attempt to maintain that all the steps I have indicated here pass as successive ideas through the minds of the birds. I have merely outlined the impression which their behavior gives to the observer. The analysis of what goes on in an avian mind is a problem which the comparative psychologist does not regard with appreciable optimism. But of the following objective facts we may, I think, be certain:

1. The flock moves from place to place by what may be termed the spread of impulse. An individual bird, moved no doubt by the hunger instinct, takes temporary leadership, and is followed to a new location by the others. There are no regularly assigned leaders, though probably the most venturesome birds assume the leadership most often.

It should be noted in this connection that Trotter (1916, p. 29) has attributed a similar type of behavior to the mammalian herd: "Each member of the flock tending to follow its neighbor, and in turn to be followed, each is in some sense capable of leadership".

2. The line of flight between two locations is usually determined by the first adventurer. Ordinarily it represents the shortest distance across an open space. The other birds gather at the point of departure and follow suit, possibly through imitation, or because the tested route appears the safest.

3. Sometimes two or three self-appointed leaders move off simultaneously in different directions. It seems then to be largely a matter of caprice which one the flock follows. Each leader may have a following, and the flock for a time become divided into two or three segments; or the flock may follow any one of the leaders. In any case a bird which ventures into a new location and is not followed by others soon loses its wanderlust and hastens to rejoin its comrades.

4. Individual birds which are finding good foraging may lag behind until the flock is some distance away. Then they appear suddenly to wake up to the fact that they have been left alone, and hurry after the flock with excited calls. Occasionally these loiterers become lost entirely; thereupon they become greatly agitated, and move rapidly from place to place, uttering the location note so loudly and continuously that I have sometimes mistaken the notes of a single bird for those of an entire flock. It is extremely probable that such lost birds attach themselves to the first flock they find, regardless of whether or not it is the one of which they originally formed a part.

5. At more or less frequent intervals the flock tends to become assembled in a relatively small space, the branches of a single oak, for example, and there to pause long enough for stragglers to catch up. It will be seen by reference to the observations above recorded that such reunions occurred at points E, J, and Q. This type of behavior is probably unmotivated, and may even be due to mechanical causes, such as the nature of the forage route; but it is of frequent occurrence, and probably is of considerable importance in keeping the flock together.

6. Call notes play an important role in flock behavior (cf. Grinnell, 1903). The principal notes are a location note, uttered more or less continuously, which functions in keeping the flock together while foraging, an alarm note, and a "confusion chorus" which is uttered by all members of the flock in concert on the appearance of certain enemies, e. g., a Sharp-shinned Hawk.

7. The method of flock movement makes evident the extreme improbability of there being any definite forage routes. The direction taken by the flock at any time is a matter of caprice, or the circumstances of the moment. Due to their dislike for crossing open spaces, however, the birds are likely to frequent areas where the vegetation is continuous and will generally avoid those where it is discontinuous, so that an impression of regularity in their forage movements may thus secondarily be given.

Whether or not the differences between the flock behavior of the Bush-tit and that of various other birds manifesting a more complicated type of flock organization are differences of kind or of degree only, is a subject for further investigation. There is a field here for much interesting and profitable work, and it is the belief of the writer that such studies are likely to be

of value in connection with the general problem of group psychology.

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Department of Zoology, University of California, June 11, 1921.

GENERA AND SPECIES

By RICHARD C. McGREGOR

I HAVE read with much interest and appreciation the article by Witmer Stone on the use and abuse of the genus[1]. Briefly stated, Doctor Stone's protest is against the excessive division of genera that has been proposed by some recent authors; he suggests that we use the broader generic divisions of a few years ago for nomenclatural purposes, restricting the finer superspecific divisions to occasions when such distinctions are required. This subject erupts more or less periodically[2], and one might derive some entertainment from a study of its cycle and predict the year of the next activity.

As ornithological nomenclature has been one of the chief sufferers from the abuse described by Doctor Stone, it would be appropriate for the *Condor* and other leading ornithological journals to publish comment on this subject. Therefore, a few words are offered for the sake of provoking discussion.

The general tendency, in ornithology at least, is to recognize finer and more trivial characters and, accordingly, to break up old groups and to name more families, genera, etc. With ever-increasing collections and the more intensive study of specimens, the systematist inevitably recognizes differences that escaped detection before, and exaggerates the significance of minor differences. The result is that the genus must be based upon slighter characters than formerly; the rank of the group is thus degraded. This may lead to a condition in which each species of a family is the representative of a genus, the interrelations of the species are no longer indicated, and the generic names become absolutely worthless.

The groups of taxonomy are imaginary and have no existence in nature.

[1]Science, vol. 51, 1920, p. 427.

[2]For example, note the activity of about five years ago, indicated by Sumner, F. B., Science, vol. 41, 1915, p. 899; Van Name, W. G., Science, vol. 42, 1915, p. 187; Colton, H. S., tom. cit., p. 307; Allen, J. A., tom. cit., p. 492.